Validation of the CERES Surface and Atmospheric Radiation Budget (SARB) using the CLAMS Aircraft Campaign and COVE Ocean Platform

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Problem of aerosol radiative forcing
Early CERES SARB Terra results

0830 A21D WCC 13
Observations and Retrievals of the Ocean Surface Radiation Field and Aerosols Using Field Campaign Data Including the Chesapeake Lighthouse and Aircraft Measurements for Satellites (CLAMS) Experiment I (joint with OS)
Presiding: T P Charlock and W L Smith, Jr, NASA Langley

Global Thermodynamics

Geothermal heating ~0.06 Wm-2 (Oort, 1992)

World Ocean heat storage from mid-1950s to mid-1990s
"warming rate of 0.3 Wm-2" (Levitus et al., 2000)

Radiative forcing by well-mixed anthropgenic gases +2.45 Wm-2 (IPCC '95)
Direct aerosol at TOA –0.2 to –0.8 Wm-2
Indirect aerosol at TOA ~0.0 to –1.5 Wm-2
Larger uncertainty in aerosol forcing in new IPCC

Well-mixed anthropogenic trace gases
Monitored accurately
Forcing computed with high confidence (thank you, spectroscopy)
Forcing at surface generally smaller than at TOA

Anthropogenic aerosols
Inadequate sampling network, uneven distribution, uncertain composition
Forcing calculations regarded as not thorough
Forcing at surface 2-4 times larger than at TOA (the absorption problem)

Radiometry: Our primary tool for monitoring aerosols and aerosol forcing

Accuracy of TOA ERBE observations:

Global annual net (SW-LW) ~ 5 Wm-2

Regional monthly uncertainty ~ 6 Wm-2

Year-to-year fidelity (if continuous) ~ 1-2 Wm-2   (CERES better by four)

Accuracy of surface observations:

Baseline Radiation Network (BSRN) operations Manual (WMO /TD-No. 879, 1998)

BSRN is a high quality standard to which the best stations may subscribe.

Quantity at surface	Capability	Goal
Direct solar irradiance	1% or 2 Wm-2	
Diffuse solar radiation	10 Wm-2	4% or 5 Wm-2
Global (SW) radiation	15 Wm-2	2% or 5 Wm-2

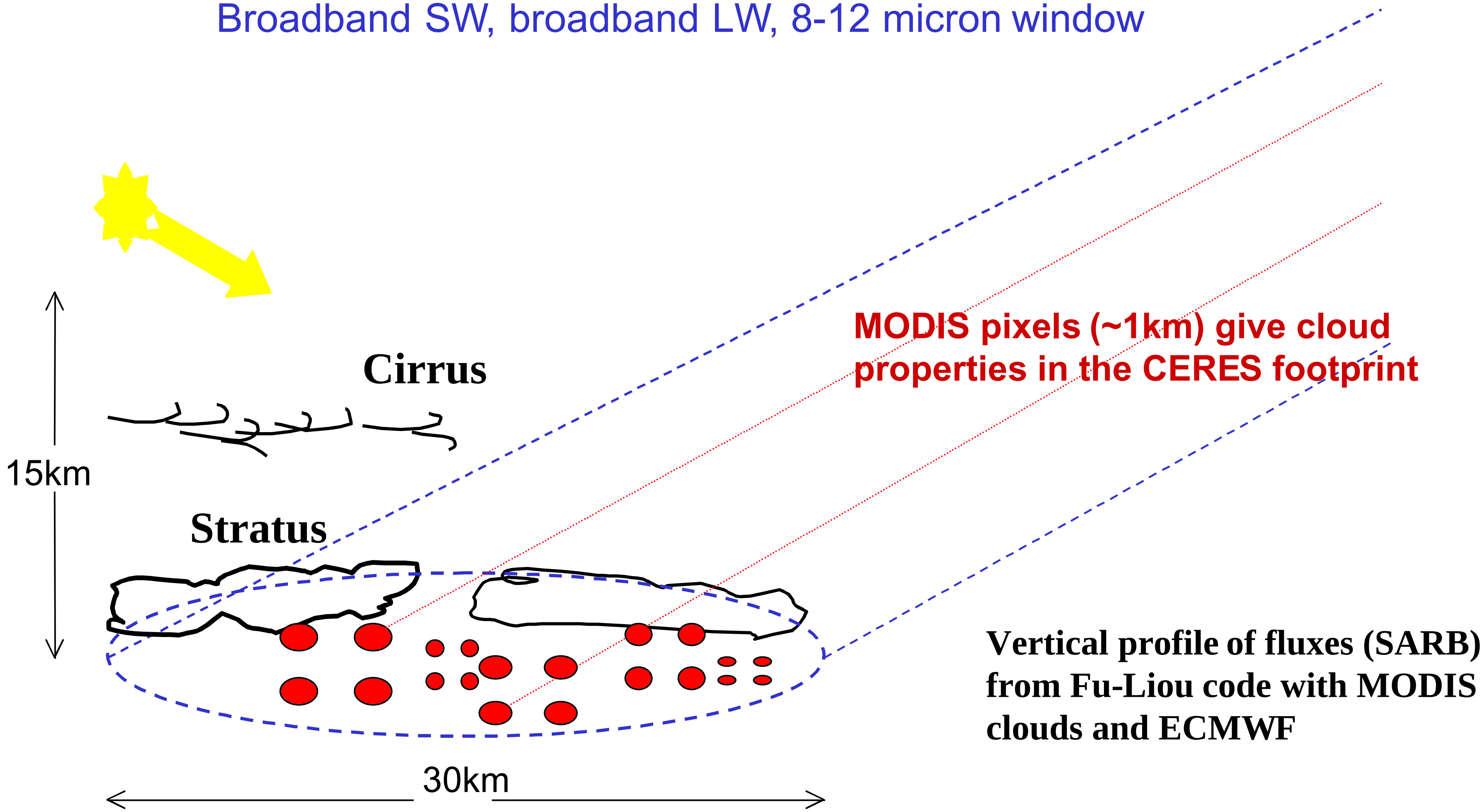
(computed – measured) insolation in clear skies: discrepancies ~10-20 Wm-2 remain

In situ measurement

Flux with a calibrated radiometer *is not at as accurate as* temperature with a mercury thermometer

Typical CERES crosstrack footprint

Broadband SW, broadband LW, 8-12 micron window



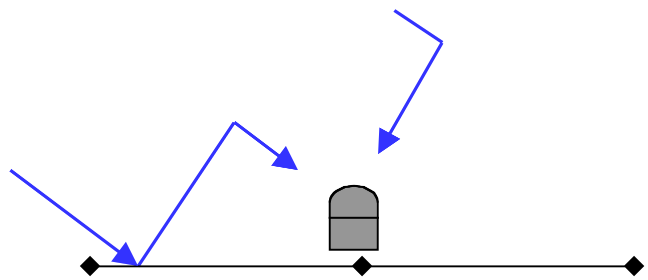
The aerosol absorption problem: need to close at surface and TOA

Mismatch of surface albedo and surface insolation in SARB.

We retrieve surface albedo for clear footprints ~10-100km

Surface insolation measured at a point is affected by surface albedo.

Clear sky: surface albedo impact on insolation is small.
Relevant albedo scale is ~10km

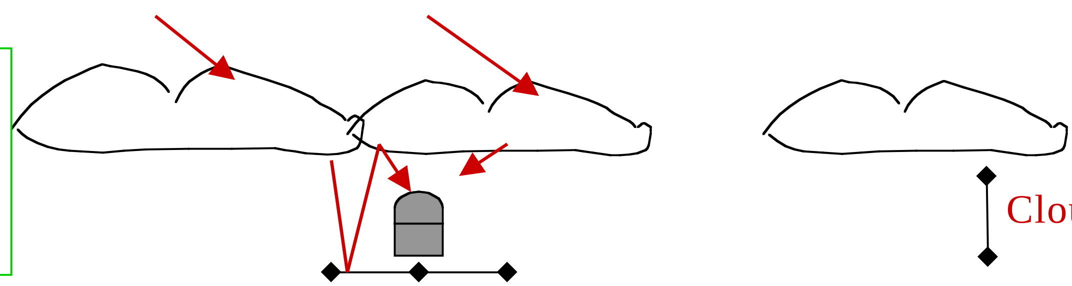


500 hPa at ~6km

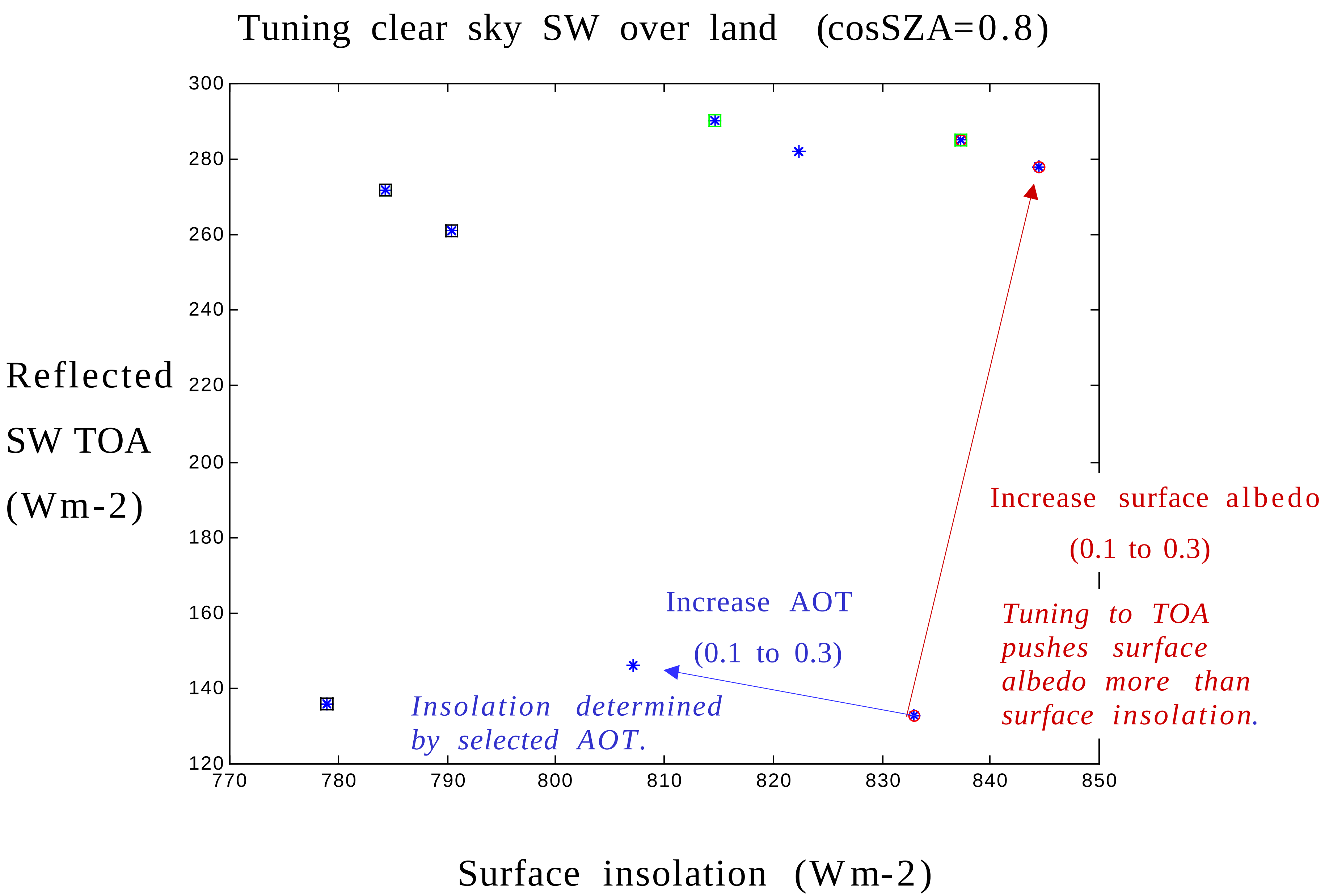
50% of Rayleigh scattering to surface comes from above 5 km

Cloudy sky: surface albedo impact on insolation can be large. Relevant albedo scale is ~2 X cloud base height.

This is not a problem at COVE sea platform, where we know the surface albedo.

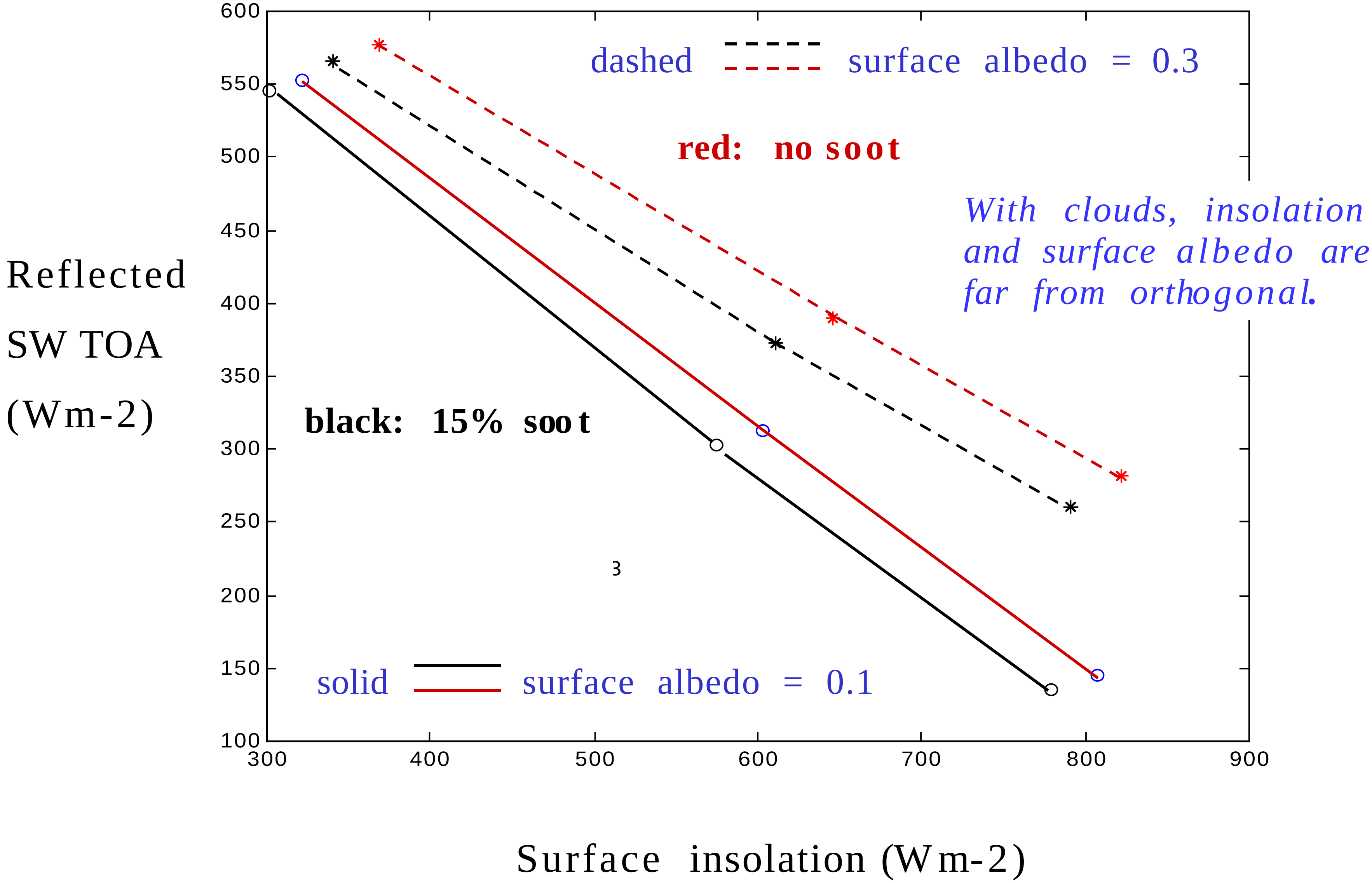


Cloud base 2km


Tuning clear sky SW over land (cosSZA=0.8)
Reflected SW TOA (Wm-2)
Surface insolation (Wm-2)
300
280
260
240
220
200
180
160
140
120
770
780
790
800
810
820
830
840
850
Increase surface albedo
(0.1 to 0.3)
Increase AOT
(0.1 to 0.3)
Insolation determined by selected AOT.
Tuning to TOA pushes surface albedo more than surface insolation.

Tuning all-sky SW over land (cosSZA=0.8)

cloud height 3km, r=8um AOT=0.3, scale ht. 1km



Surface and Atmospheric Radiation Budget (SARB)

"CRS" bubble in CERES processing

Tuned in clear footprints:

AOT

Surface albedo

PW and UTH

skin T

Input for modified Fu-Liou code

T(z),H2O(z)	ECMWF
O3(z)	SBUV-HIRS (SMOBA – Yang and Miller)
Clouds	VIRS (Minnis Cloud WG) Area, height, optical depth Particle size and phase Estimate of geometrical thickness
Aerosol optical thickness (AOT)	VIRS (Stowe) for some clear ocean 6-hourly Collins-Rasch assimilation (AVHRR+NCEP+model) OPAC-GADS optical properties guided by assimilation Fixed estimates of scale heights

Ocean albedo: LUT to Jin coupled air-sea model

Preliminary Terra processing uses GFDL (Soden) Chemical Transport Model aerosol, which is MONTHLY AVERAGED.

CERES TRMM (Jan-Aug 98) -- not Terra

ARM SGP E13 (collocated with Central Facility)

	Obs Mean	N	Bias Obs-CRS	RMS	Cld Forc All-Clr
ALL SKY					
LW Dn Sfc	352	448	1	18	17
LW Up Sfc	421	423	2	16	
SW Dn Sfc	431	258	-18	58	-106
SW Up Sfc	85	258	9	18	
LW Up TOA	248	454	0	4	-26
SW Up TOA	224	258	2	10	87
OVERCAST					
SW Dn Sfc	242	66	-23	86	-312
CLEAR VIRS					Aer Forc
SW Dn Sfc	516	94	-19	26	-16/0.6
					SW/ LW
CLEAR VIRS + pyranometer					
SW Dn Sfc	400	18	-10	14	-12/ 0.5
SW direct			-2		
SW diffuse			-8		

6 Footprints enveloping COVE on “Golden Day” (17 July 2001)

SARB TUNED RETRIEVALS (black)

CERES TOA OBSERVATIONS (blue)

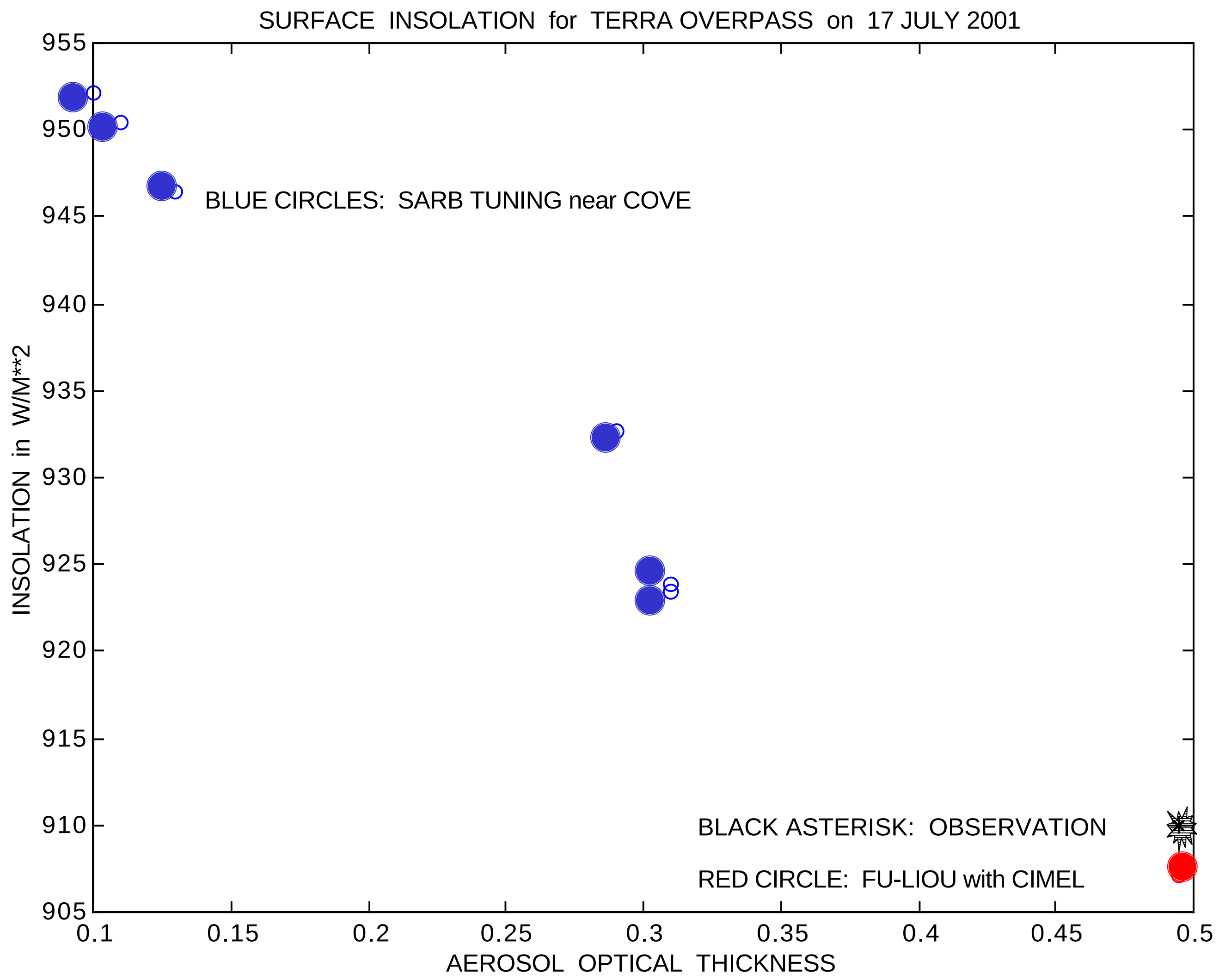
AOT	SWdown	SW TOA		LW TOA		
0.31	923.4800	93.16	93.39	279.38	277.18	
0.31	923.8500	90.71	90.96	279.44	276.90	
0.13	946.5200	84.63	87.43	277.95	278.11	
0.10	952.1500	80.37	85.50	279.51	279.19	
0.11	950.4500	82.00	86.18	278.99	278.94	
0.29	932.7500	98.99	98.79	278.08	278.19	
0.2083	938.7170	88.31	90.35	278.89	278.08	Mean
0.0956	17.18	6.57	4.65	0.64	0.83	RMS

910 = observed SWdown at COVE

907 = computed with Fu-Liou and Cimel AOT

INSOLATION

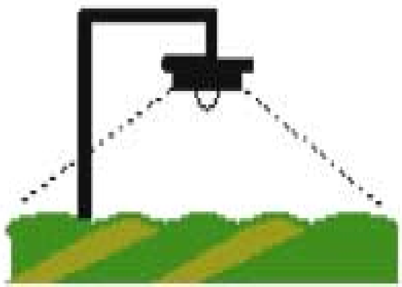
(W/m**2)



Reserve slides follow

U(large FOV(land)) ≠ U(radiometer FOV)

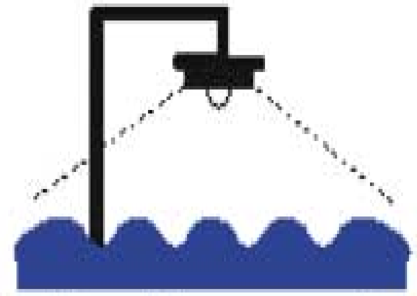
$$\frac{\int U dA}{\int dA} \neq \frac{\int U dt}{\int dt}$$



Inhomogeneous

U(large FOV(ocean)) ≈ U(COVE radiation)

$$\frac{\int U dA}{\int dA} \approx \frac{\int U dt}{\int dt}$$



Quasi-homogeneity

U - Upwelling radiation at the surface, t - time, A -Area(FOV)

July 17 1615Z

CIMEL AOT=0.929,0.799,0.620,0.495,0.258,0.135,0.084

CIMEL PW =3.88   U0 = 0.9407

Aug 01 1545Z

CIMEL AOT=0.138,0.114,0.081,0.068, 0.042,0.025 ,0.021

CIMEL PW =2.43   U0 = 0.8937

CAVE COVE/CERES OBSERVATION

	SWDN	Direct	Diffuse	OBS CERES SW
July 17	910	686	223	81-124
Aug 01	912	826	86	91-116

Large spread of observed (OBS) CERES TOA SW due to

- observations at multiple view angles
- sun glint

Off Line model calculations (modified Fu-Liou code & CIMEL AOT &PW)

	SWDN	Direct	Diffuse	TOA SW
July 17	907.07	686.69	220.38	105.27
Aug 01	915.16	833.31	81.85	80.72

Fu-Liou code compares very well with COVE surface observations for these clear cases.